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SPECIFICATION <EXCERPT>

[0049]

[Embodiment of the Present Invention]

FIG. 1 is a block diagram showing an embodiment of the data coding apparatus which embodies a data coding method according to the present invention. In the data coding apparatus shown in the diagram, an audio encoder 102 compression-encodes an input audio signal supplied to its audio input terminal, and outputs the compression-encoded audio signal to a multiplexing apparatus 113, and a video encoder 101 compression-encodes an input video signal supplied to its video input terminal, and outputs the compression-encoded video signal to the multiplexing apparatus 113. In this case, it is assumed that a stream outputted from the audio encoder 102 is an MPEG-2 audio stream (audio layer), and that a stream outputted from the video encoder 101 is an MPEG-2 video stream (video layer) shown in FIG. 15(C).

[0050]

The multiplexing apparatus 113 packetizes the input MPEG-2 video stream and MPEG-2 audio stream by time-division multiplexing (packetizing) as shown in FIG. 15(A). Although not shown, a subtitle stream may also be inputted to the multiplexing apparatus 113, and may be multiplexed with the video stream and the audio stream. In such case, the MPEG-2 system stream outputted from the multiplexing apparatus 113 is as shown in FIG. 15(A).

[0051]

An input terminal of an entry point data memory circuit 133A is connected to an output terminal of either the video encoder 101 or an entry point detector 131. The entry point data memory circuit 133A receives data of an entry point (data of an I-picture generation

point) from the connection destination, and store the data. A TOC data generator 156 generates TOC (a table of contents) data based on the contents of the entry point data memory circuit 133A. The TOC data include a name of a disk, the name of each chapter on the disk, the start address of each chapter, the reproduction time of the disk, the reproduction time of each chapter, the start address of each entry sector, and the like.

[0052]

The multiplexed stream outputted from the multiplexing circuit 113 is temporarily stored in a DSM (Digital Storage Medium) 110 for temporal storage, and the multiplexed stream read out from the DSM 110 is supplied to a TOC suffix circuit 150. The TOC suffix circuit 150 adds the TOC data generated by the TOC data generating circuit 156 to the multiplexed stream, and supplies the same to a picture header detecting and PSM data generating and overwriting circuit 155. The picture header detecting and PSM data generating and overwriting circuit 155 detects a picture header, generates PSM (program stream map) data which includes information representing the data lengths in bytes from the beginning of an entry sector to the end of the first-appearing P-picture and from the beginning of the entry sector to the end of the second-appearing P-picture, and writes the PSM data into at least the entry sector. Generating the PSM data is a feature of the present invention. In this case, the multiplexing apparatus 113 reserves an area for storing the generated PSM data in the entry sector in the multiplexed stream, and the generated PSM data is written into this area. A detailed description of the PSM data will be provided later.

[0053]

The output of the picture header detecting and PSM data generating and overwriting circuit 155 is supplied to a sector header suffix circuit 151, where the multiplexed stream is divided into sectors with a sector header added to each of the sectors. The

output of the sector header suffix circuit 151 is inputted to an ECC encoder 152, and is encoded for error correction by the ECC encoder 152.

[0054]

A modulating circuit 153 that receives the output data from the ECC encoder 152 performs eight to fourteen modulation (EFM), and the modulated output data is supplied to a cutting machine 154. Next, the cutting machine 154 forms pits in a disk 160 in accordance with the data supplied from the modulating circuit 153, thereby the multiplexed stream data is written on the disk 160. A DVD disk is produced, for example, through press-molding of this original disk 160.

[0055]

In this way, the data coding apparatus shown in FIG. 1 encodes an audio signal and a video signal inputted thereto, and the multiplexing apparatus 113 packetizes, using time-division multiplexing, the audio signal and the video signal to produce a multiplexed stream. Furthermore, the picture header detecting and PSM data generating and overwriting circuit 155 generates PSM data, and writes the PSM data into the multiplexed stream. The multiplexed stream is written onto the disk 160.

[0056]

Here, FIG. 2 shows an embodiment of the multiplexed stream, that is, an MPEG-2 system stream, outputted from the picture header detecting and PSM data generating and overwriting circuit 155. For simplicity, only video data and audio data are multiplexed in the diagram. As shown in the diagram, the MPEG-2 system stream includes audio data inserted in certain portions to ensure that the sound is not interrupted during reproduction, and video data of I-, P-, and B-pictures inserted among the audio data.

[0057]

Entry sectors are written at entry points. The positions of

the entry points at which the entry sectors are written are denoted as entry sector n, entry sector n+1,..., and so forth. The position at which an entry point is written is predetermined to be immediately before an I-picture, so that a complete picture can be displayed instantly when a pickup reads the data from the entry sector. Accordingly, although audio data may be present between the entry sector and an I-picture, video data including a picture header of a P- or B-picture cannot be present therebetween.

[0058]

FIG. 3 shows a layout of an entry sector. As shown in the diagram, the entry sector includes pack_header with optional system_header, a PSD (Program Stream Directory), a PSM (Program Stream Map), and other packets. FIG. 4 shows the syntax of the PSM. As shown in the diagram, the PSM includes packet_ start_code_prefix of 24 bits forming a unique code, map_stream_id of 8 bits, program_stream_info composed of an arbitrary number of global descriptors, stream_type, elementary_stream_info including elementary_stream_descriptor in an arbitrary number, and the like.

[0059]

FIG. 5 shows the syntax of the Elementary Stream Descriptors which are composed of either (i) dvd_video_descriptor and ip_ipp_descriptor if the stream is video data, or (ii) dvd_audio_descriptor and ISO_639_language_descriptor indicating language if the stream is audio data, or (iii) dvd_subtitle_descriptor and ISO_639_language_descriptor indicating language if the stream is subtitle data. In addition, other items of information shown in FIG. 5 are also added thereto.

[0060]

The ip_ipp_descriptor among the elementary_stream_descriptor is a descriptor unique to the present invention, and the syntax of an IP_IPP_descriptor is shown in FIG. 6. As shown in the diagram, the ip_ipp_descriptor consists of

descriptor_tag of 8 bits signifying a descriptor of ip, ipp, description_length of 8 bits signifying the length of the descriptor, bytes_to_first_P_pic of 32 bits signifying the number of bytes from the first byte of the current entry sector to the last byte of a first-appearing P-picture, and bytes_to_second_P_pic of 32 bits signifying the number of bytes from the first byte of the current entry sector to the last byte of the second-appearing P-picture.

[0061]

The bytes_to_first_P_pic and bytes_to_second_P_pic represent the data lengths, and the data length range is as shown in FIG. 2. It is appreciated that the number of offset bytes indicated by bytes_to_first_P_pic and bytes_to_second_P_pic includes not only bytes of I- and P-pictures but also bytes of B-pictures and audio packets as shown in FIG. 2. FIG. 7 shows the syntax of the global descriptors. The PSD included in each entry sector represents information items of distances from the current entry sector to the preceding entry sector and the following entry sector, and information items of the distances to the entry sectors after a lapse of one second, three seconds, and so on. These information items of distances are described as offset addresses.

[0062]

Next, FIG. 8 is a block diagram of an embodiment of the data decoding apparatus which is according to the present invention and which embodies a data decoding method according to the present invention. In FIG. 8, elements corresponding to the elements shown in FIG. 17 are denoted by the same reference numerals. In the diagram, a disk 1 is caused to rotate at a predetermined rotation rate by a spindle motor (not shown), and a laser beam is projected from a pickup 2 to a track on the optical disk 1 to read digital data compressed according to MPEG and recorded on the track. The digital data is EFM-demodulated by a demodulating circuit 3 and inputted to a sector detecting circuit 4. In addition, the output of

the pickup 2 is supplied to a phase-locked loop (PLL) circuit 9, and the phase-locked loop circuit 9 recovers a clock. The recovered clock is supplied to both the demodulating circuit 3 and the sector detecting circuit 4.

[0063]

The digital data recorded on the disk 1 includes a multiplexed stream recorded in units of a fixed-length sector including a sector sync and a sector header added at the beginning of the sector. The sector detecting circuit 4 detects the delimiter of sectors when the sector sync is detected, and detects a sector address etc., based on the sector header. Both of them are supplied to a control circuit 6. The demodulated output is supplied via the sector detecting circuit 4 to an ECC (error correction) circuit 33 which executes error detection and correction. The ECC circuit 33 supplies the error-corrected data to a ring buffer 5 so that the error-corrected data is written in the ring buffer 5 under control of the control circuit 6.

[0064]

In addition, the output of the ECC circuit 33 is supplied to a PSM detecting circuit 40. In the special reproduction mode, the PSM detecting circuit 40 detects the PSM information in the entry sector from the stream data read from the disk 1, and supplies the PSM information to the control circuit 6. The control circuit 6 receives this PSM information and uses it to control the writing of stream data into the ring buffer 5 in a special reproduction mode, according to the information relating to the number of offset bytes indicated by the IP IPP descriptor. Here, the stream data includes an I-picture that appears immediately after the entry sector and two P-pictures that appear after the I-picture.

[0065]

Under control of a system controller, a tracking servo circuit and a focus servo circuit control focusing and tracking of the pickup

2, respectively, in accordance with a focus error signal and a tracking error signal obtained from the information read out by the pickup 2. Here, the control circuit 6 designates, by a write pointer WP, a write address for writing the sector into the ring buffer 5, based on the sector address of each sector detected by the sector detecting circuit 4. Furthermore, the control circuit 6 designates, by a read pointer RP, a read address from which the data is read from the ring buffer 5, based on a code request signal obtained from a video code buffer 10 in a post-stage. The data read from the position designated by the read pointer RP is supplied to a demultiplexer 32.

[0066]

The data recorded on the disk 1 is coded data including multiplexed video data, audio data, subtitle data, and the like. The demultiplexer 32 separates the data into the video data, audio data, and subtitle data, and supplies the video data, audio data, and subtitle data to a video decoder 20, an audio decoder, and a subtitle decoder, respectively. As a result, the video data read out from the ring buffer 5 is separated by the demultiplexer 32, and is stored in the video code buffer 10. The stream data from an I-picture to the second P-picture which appears after the I-picture includes packets other than the video packets, as shown in FIG. 2. In the special reproduction mode, any unnecessary data, that is, the packets other than the video data are excluded by the demultiplexer 32.

[0067]

Furthermore, the data stored in the video code buffer 10 is supplied to a picture header detector 34 at which the picture header thereof is detected, which enables detection of the picture type information signifying the picture type I, P or B, and the temporal reference (TR) signifying the frame order in the GOP. The detected picture type information is supplied to a picture data selecting circuit 35 at which only the I- and P-pictures are selected according

to the picture type information outputted from the picture detector 34 in the special reproduction mode, and the selected pictures are supplied to an inverse VLC circuit 11. In the normal reproduction mode, the picture data selecting circuit 35 is caused to output all of the pictures without selecting some of the pictures. This control is performed by system control although not shown.

[0068]

The data supplied to the inverse VLC circuit 11 is processed using inverse VLC therein. After the inverse VLC is completed, the data is supplied to a dequantizing circuit 12 and code request signals are provided to the video code buffer 10, so that new data is transferred from the video code buffer 10. Furthermore, the inverse VLC circuit 11 outputs a quantization step size to the dequantizing circuit 12, and outputs motion vector information to a motion compensating circuit 15. The dequantizing circuit 12 dequantizes the input data in accordance with the specified quantization step size, and outputs the dequantized data to an inverse DCT circuit 13. The inverse DCT circuit 13 processes the input data using inverse DCT, and supplies the processed data to an adding circuit 14.

[0069]

The adding circuit 14 adds the output of the inverse DCT circuit 13 with the output of the motion compensating circuit 15 in accordance with the picture type (I, P or B), and supplies the resulting data to a frame memory bank 16. Next, the data are read from the frame memory bank 16 under control to ensure the original frame order shown in FIG. 13(A). The data is converted by a digital-to-analog (D/A) converter 17 into an analog video signal, and is displayed on a display 18.

[0070]

In response to a code request signal from the video code buffer 10, the control circuit 6 supplies the data stored in the ring

buffer 5 to the video code buffer 10. When the amount of data transferred from the video code buffer 10 to the inverse VLC circuit 11 is decreased, for example, as a result of continuous data processing of simple pictures, the amount of data transferred from the ring buffer 5 to the video code buffer 10 is also decreased. Consequently, the amount of data stored in the ring buffer 5 may increase, and the write pointer WP may pass the read pointer RP to cause overflow of the ring buffer 5.

[0071]

To prevent this, the control circuit 6 calculates the current amount of data stored in the ring buffer 5 based on the address positions of the write pointer WP and the read pointer RP that are under control of the control circuit 6. When a current data amount exceeds a predetermined reference value, a track jump deciding circuit 7 determines that the ring buffer 5 may overflow, and sends a track jump command to the tracking servo circuit 8.

[0072]

The data transfer rate from the ring buffer 5 to the video code buffer 10 is preset to be equal to or lower than the data transfer rate from the ECC circuit 33 to the ring buffer 5. This allows free transmission of a code request for data transfer from the video code buffer 10 to the ring buffer 5 regardless of the timing for a track jump. In this way, the data reproduction apparatus shown in FIG. 8 causes the pickup 2 to perform a track jump according to the storage capacity of the ring buffer 5, and thus it can prevent the video code buffer 10 from overflowing or underflowing irrespective of the complexity or simplicity of the video recorded on the disk 1, and sequentially reproduce the video having uniform image quality.

[0073]

In the case where the video data recorded on the disc 1 is reproduced in a normal reproduction mode, it is assumed that data of I, P and B pictures I_0, B_{-2}, B_{-1} P_0, B_0, B_1,... are recorded on the disk

1 in the order shown in FIG. 14(B). In this case, one GOP is composed of fifteen frames of pictures including one frame of I-picture, four frames of P-pictures, and ten frames of B-pictures. Here, normal reproduction of the pictures is performed by sequentially reading and decoding the coded data in recording order and displaying the decoded data in the order shown in FIG. 14(A).

[0074]

More specifically, at the time of decoding the I-picture I_0, the decoded output from the inverse DCT circuit 13 is supplied directly to the frame memory bank 16 because the picture of this type is not subjected to inter-frame prediction. However, at the time of the B-picture B_{-2}, the previously decoded P-picture and I-picture I_0 both of which are used as references in predictive-coding the B-picture B_{-2} are supplied from the frame memory bank 16 to the motion compensating circuit 15 in which a motion predicted picture is generated in accordance with the motion vector information supplied from the inverse VLC circuit 11. The generated motion predicted picture is supplied to the adding circuit 14 in which the motion predicted picture is added to the output of the inverse DCT circuit 13, and thereby the B-picture B_{-2} is decoded and stored in the frame memory bank 16.